

## TWO-WAY SLIT VALVE

### **BACKGROUND OF THE INVENTION**

#### **1. FIELD OF THE INVENTION**

The present invention is directed to a slit valve that enables two-way fluid flow, and in particular a slit valve for use with implantable, inflatable medical devices such as a gastric balloons for the treatment of obesity.

#### **2. DESCRIPTION OF THE RELATED ART**

There are a wide variety of known inflatable devices that can be implanted in the body.

One such inflatable implantable medical device is a gastric balloon, as described in U.S. Patent No. 5,084,061, or commercially available as the BioEnterics Intragastric Balloon System (sold under the trademark BIB®). These devices are designed to provide therapy for moderately obese individuals who need to shed pounds in preparation for surgery, or as part of a dietary or behavioral modification program.

The BIB System, for example, consists of a silicone elastomer gastric balloon that is inserted into the stomach and filled with fluid. Commercially available gastric balloons are filled with saline solution or air. The gastric balloon functions by filling the stomach and enhancing appetite control. Placement of the gastric balloon is non-surgical, usually requiring no more than 20-30 minutes. The procedure is performed endoscopically in an outpatient setting, using local anesthesia and sedation. Placement is temporary, and gastric balloons are typically removed after six to twelve months.

There are known in the prior art a variety of valves for use with such gastric balloons. For example, the valve described in U.S. Patent No. 5,084,061, shown in Fig. 1, consists essentially of a leaf valve (also known as a duckbill valve) comprising two relatively flat pieces of silicone elastomer bonded along their longitudinal edges and affixed by adhesive to the end of the valve stem. In operation, a filler tube, which is usually a plastic or silicone tube containing a stainless steel stiffening rod, is inserted through an X-shaped slot, through a hole, through a tubular valve stem, through a second X-shaped slot in the membrane, and through the leaf valve until the filler tube itself is in the interior of the shell. In such a position, both addition and withdrawal of fluid can be accomplished. For addition of fluid only, the filler tube does not need to penetrate through the leaf valve.

However, valves of this sort have several disadvantages. Initially, these valves are prone to leaking. One way in which a duckbill valve may develop leaks is through the initial filling of the balloon when one of the flat pieces of elastomer becomes kinked or develops a curvature through which the fluid can pass. Another  
5 way is through the fluid removal process, which requires the insertion of the filler tube completely through the valve and into the interior of the shell. Following removal of a portion of the fluid and the filler tube, the leaf valve can remain partially open. This causes even greater amounts of the fluid to be released from the implant. Accordingly, there is a need for a valve that does not leak following either  
10 filling or removal of fluid from the shell.

Second, the prior art leaf valves face opposing problems in that it is necessary to reduce the pressure necessary to insert the filler tube into the valve to ease in installation and filling, but if there is not a sufficiently tight fit between the filler tube and the valve, then the pressure of the fluid in the balloon or valve may  
15 force the filler tip out of the valve before filling is complete. Further, it is necessary to consider the amount of force necessary to remove the fill tube from the valve. Current designs, such as that discussed above, often require too much pressure to insert the filler tube into the valve and too much pressure to remove the filler tube from the valve. Alternatively, in instances where the pressure necessary to insert  
20 and remove the filler tube are not great, the filler tube may pop out of the valve while filling the balloon. Accordingly, there is a need for a valve that promotes easy insertion and removal of the filler tube, but does not force the filler tube out of the valve while filling the balloon. Prior art leaf valves are also unsuitable at fluid inflation pressures above 30 psi, which may damage the valve.

25 Finally, the prior art duckbill valves have the shortcoming that they are only one-way valves. They cannot be used to direct fluid flow in both directions without inserting a tube completely through the valve. Situations arise where it is preferable to have a two-way valve. For example, when a device absorbs additional fluid through osmosis after being implanted in the body and filled to a proper volume, it  
30 may be desirable to reduce the fluid volume of that implant. In the duckbill valve described above, no amount of pressure on the interior of the balloon will permit egress of the fluid contained therein. Accordingly, there is a need to a valve that is

capable, of permitting back flow of fluid (i.e. from the interior to the exterior), while generally preventing egress of fluid when under normal pressure.

Another type of valve often used in implant technology is a diaphragm valve, such as a that discussed in U.S. Patent No. 6,419,699 assigned to McGhan Medical Corporation. The diaphragm valve requires insertion of a rigid male component on the inflation tube to open the valve and allow fluid transfer. Upon removal of the inflation tube, fluid pressure within the implant forces the valve closed and creates a leak proof seal. As with the leaf valve, such a valve does teach any means for backflow through the valve.

Other valves that are used in medical applications include a connector for an instrument insertion passage described in U.S. Patent No. 5,599,327 ("the '327 patent"), a non-binding surgical valve as described in U.S. Patent No. 5,916,198 ("the '198 patent"), and a needle less injection site as described in U.S. Patent No. 6,261,268 ("the '268 patent"). Each of these valves or connectors has shortcomings that are addressed by the present invention. Initially, both the '327 and the '268 patents contemplate an opening in the valve that forms a seal with the application of mechanical pressure by a medical instrument. Accordingly, both the '327 and '268 patents require the use of bulky components and mechanical force to create a seal. Such components and use of mechanical force are not conducive for use with implant technology. Further, the '198 patent describes a one-way valve that is closed by insufflation gases acting on an interior surface of the valve via a passage in one of the valve segments. Accordingly, the valve contemplated by the '198 patent does not overcome the shortcomings of the prior art discussed above.

Therefore, the present invention is directed at overcoming these problems associated with the prior art valves. The present invention is related to a two-way valve that is usable in an implantable medical device such as a gastric balloon.

These and other characteristics of the present invention will become apparent from the further disclosure to be made in the detailed description given below.

#### **SUMMARY OF THE INVENTION**

The present invention is directed to a two-way valve having first and second ends. The two-way valve includes a substantially cylindrical valve body having a slit connecting the first and second ends of the valve and concave sections formed in the first and second ends.

The present invention is further directed to a slit valve having a flange surface with an opening therein. The slit valve has a valve body connected to the flange surface and a chamber formed in the valve body for accepting an inflation tube inserted through the opening in the flange surface. The slit valve has a concave section at one or both ends, which are connected by a slit formed in the valve body.

The present invention is also directed to an implantable, inflatable apparatus having a slit valve. The slit valve includes a flange surface having an opening. The slit valve also includes a valve body connected to the flange surface, a first chamber formed in the valve body for accepting an inflation tube inserted through the opening in the flange surface, a concave section located at one or both ends of the valve, and a slit formed in the valve body connecting the two ends.

The present invention is also directed to a medical apparatus for the treatment of obesity. The medical apparatus includes a balloon formed of a suitable polymer or elastomer material for insertion into the stomach, and a slit valve for communication of a fluid from an inflation tube to the balloon. The slit valve includes a flange surface having an opening therein, a valve body connected to the flange surface, a first chamber formed in the valve body for accepting the inflation tube inserted through the opening in the flange surface, a concave section located at one or both ends of the valve, and a slit formed in the valve body connecting the two ends.

Further characteristics, features, and advantages of the present invention will be apparent upon consideration of the following detailed description of the invention taken in conjunction with the following drawings, and in which:

**BRIEF DESCRIPTION OF THE DRAWINGS**

- Fig. 1 is a cross sectional view of a prior art gastric balloon with a one-way valve;  
Fig. 2 is a cross-sectional view of a prior art one-way valve;  
Fig. 3 is a side view of a two-way slit valve according to one of the embodiments of  
5 the present invention;  
Fig. 4 is a cross-sectional view of the two-way valve shown in Fig. 3;  
Fig. 5 is a close-up view of a portion of the two-way valve shown in Fig. 4;  
Fig. 6 is a top view of the two-way valve according to another aspect of the present  
invention;  
10 Fig. 7 is side view of a filler-tube according to another aspect of the present  
invention;  
Fig. 8 is a side view of an inflation tip according to another aspect of the present  
invention;  
Fig. 9 is a cross-sectional view of the inflation tip of Fig. 8; and  
15 Fig. 10 is a cross-sectional view of a two-way valve according to another aspect of  
the present invention.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

A slit valve 10 in accordance with a first embodiment of this invention is  
20 shown in Fig. 3. The valve comprises a valve body 14 and a flange 12. With  
respect to the description of this invention, the end of the valve 10 on which the  
flange 12 is located will be called the top of the valve and the opposite end the  
bottom. The valve 10 is preferably formed of an elastomeric material such as  
silicone, however, other materials may be used without departing from the scope of  
25 this invention. The valve body 14 is preferably molded in a substantially cylindrical  
shape. The cylindrical shape is preferred as it provides added rigidity and stiffness  
for the valve.

Figs. 4 and 5 show cross-sectional views of the valve 10. Fig. 6 shows a top  
view of valve 10. Starting at the flange surface 12 of the top of the valve 10, there is  
30 an opening 16 through the flange 12 that is in communication with interior surfaces  
of the valve 10. Immediately below the opening 16 is a first chamber 18. Beneath  
the first chamber 18 is a neck 19. The neck 19 separates the first chamber 18 from a  
second chamber 26. At the bottom of the second chamber is a concave surface 20.

The concave surface 20 is preferred because it provides guidance to a probe in the event that the sealing properties of valve 10 need to be overcome mechanically. The concave surface 20 assists in the guidance of a probe (not shown) that can be used to force the valve to open and allow for reverse flow of fluid contained by the valve 10.

5       Following the concave surface 20 is a slit 24 in a substantially solid portion of the body 14. The slit 24 connects and is in fluid communication with a second surface 22, which may be concave as shown, or flat. In an application such as a gastric balloon, fluid enters the balloon shell as it exits the bottom side of the slit 24. The slit 24 may be lubricated with silicone oil. The use of silicone oil eases the  
10       insertion of a removal tip (not shown) in instances where it is desired to overcome the sealing properties of the valve 10, and serves to reduce the chance of cross-linking where the valve body 14 is made of silicone.

      Fig. 7 depicts a filler tube 30. The filler tube is comprised of a long flexible tube 34 having a lumen therethrough, an injection tip 32, and a connector 35 for  
15       connecting the filler tube to a fluid supply (not shown). The flexible tube 34 may be provided with reference length markers 36 to provide medical personnel with a visual indication of the position of fill tube 30 inside the patient. As shown in Figs. 8 and 9, the injection tip 32 has an orifice 37 extending therethrough that allows for fluid communication through the flexible tube 34, and the injection tip 32. One of  
20       the ends of the injection tip may be tapered into a wedge shape 38 having its smallest cross-section at the distal end of the injection tip 32. The wedge shape 38 assists in the insertion of the injection tip 32 into slit valve 10. Further, the injection tip may include a reduced diameter portion 40, and an insertion stop 42 for positively engaging the opening 16 of valve 10. The other end of the injection tip 32  
25       is provided with barbs 44 to retain flexible tube 34 in fluid-tight engagement with the injection tip.

      In use, the filler tube 30 is connected to the valve 10 by inserting the injection tip 32 into opening 16 of the valve 10. The injection tip 32, upon full insertion into the valve, extends to a point approximately even with a top surface of  
30       the second chamber 26. The substantial wedge shape 38 of the injection tip matches the orientation of the first chamber 18, and the narrow cross-sectional portion of the injection tip 32 is held firmly by the neck 19 of valve 10 to form a seal preventing the egress of fluid from the second chamber 26 into the first chamber 18 and out

through the opening 16. The insertion stop 42 on the injection tip 32 prevents the injection tip from being inserted into the valve 10 beyond a pre-determined point. Upon full insertion, the insertion stop 42 rests against the flange 12 of valve 10. The opening 16 is of a size that, upon insertion of the injection tip 32, a second seal is  
5 formed by the interference of the flange 12 and the reduced diameter portion 40 of the injection tip. This second seal further insures that fluid does not exit the valve 10 and prevents other contaminants from entering the valve 10.

The valve 10 may be attached to an inflatable medical device such as a gastric balloon, a mammary implant, such as a Becker-style breast implant, a tissue  
10 expander, or the like. Other non-inflatable applications of the valve include devices such as a shunt drug delivery or therapeutic delivery system, a feeding tube, or the like. Accordingly, these variations are contemplated within the scope of the present invention. Where the device is a gastric balloon, the valve 10 is attached to the shell substantially as shown in Prior Art Figs. 1 and 2. The flange surface 12 is placed  
15 flush with the exterior surface of the balloon and may be covered by an elastomeric sheath material that bonds the components together forming an integral gastric balloon and valve combination. The gastric balloon is inserted into a patient in a deflated state and inflated after insertion. Following insertion of the gastric balloon, a fluid, typically sterile saline, is injected into the gastric balloon via the filler tube  
20 30. Other fluids, including air, silicone, pseudogel, oil, etc., may be used to fill an implant.

To inflate the gastric balloon, the valve 10 must have a slit 24. The slit 24 is preferably a single separation of two sides of the valve body 14. The slit 24 is formed during manufacturing by inserting a sharp thin tool (not shown) into the  
25 valve body 14. The length of the slit 24 is variable depending on the application of the valve and the desired opening pressure of the valve. In certain applications it may be necessary to insure that slit valve permits backflow more readily. In such instances, a shorter slit length would be used, whereas in instances where greater pressure must be contained by the valve, a longer slit length is desirable.

30 To effectuate inflation via the filler tube 30, the injection tip 32 is inserted into the opening 16 of the flange 12. The distal end of injection tip 32 extends to form a seal with neck 19. When pressurized fluid is injected through the filler tube 30 and orifice 37 of the injection tip 32, a higher pressure is created in the second

chamber 26 having two effects. The first is to increase the sealing pressure of the neck 19 on the injection tip 32. The second effect is to force the slit 24 to open. The decreased wall thickness of the valve body 14 in the area of the second chamber 26 is more readily deformed by the pressurized fluid injected into the second chamber 26 than the area of the slit 24. The increased pressure causes the second chamber 26 to expand in a direction substantially perpendicular to the direction of the slit 24. This expansion in turn causes the slit 24 to be opened and permits the flow of fluid from the second chamber 26 through the slit 24 and into the implant. The opening of the slit is assisted by the concave surface 20. Similarly, if the second surface 22 is also concave, sufficient pressure may be applied to the shell to overcome the backflow resistance of the valve to permit the flow of fluid through the slit 24 to the exterior of the implant. Due to the relative sizes of the second chamber 26 and the concave surface 22, a far greater pressure is required to permit the backflow of fluid from the implant out of the valve than is required for inflation. For this reason the balloon or other implant may also be deflated or reduced in volume by inserting a small diameter probe or tube completely through the valve and into the interior of the implant shell. Concave surface 20 assists in guiding the small-diameter probe or tube into and through the valve body 14.

The valve 10 and the filler tip 32 when used in combination create a system that overcomes many of the shortcomings of the prior art. Through the use of the opening 16 and its interaction with the reduced diameter portion 40 of the injection tip 32, and also because of the interaction of the neck 19 with the injection tip 32, the injection tip is held firmly in place and is prevented from being forced out of the valve 10 during the injection of fluid through the valve 10. Further, because of these same features, withdrawal of the injection tip 32, when desired by the user, is greatly eased requiring less than 4 lb (17.8 N) of force to remove the tip from a balloon filled to 700 cm<sup>3</sup>. Still further, the valve 10 provides for a device that does not leak under normal operating conditions yet still allows for two-way flow. The valve of the present invention allows continuous fluid flow at 30 psi (2.11 Kg/cm<sup>2</sup>) and can safely withstand fluid fill pressures of up to 40 psi (2.81 Kg/cm<sup>2</sup>) without damage to the valve.

Fig. 10 depicts another aspect of the present invention. Fig. 10 shows a valve 11 having many of the features of the valve 10 shown in Figs. 3-6. Valve 11



has a first concave surface 20, a second concave surface 22, and a slit 24, all housed in a body 14. The valve 11 operates in a similar fashion to valve 10. Upon application of a predetermined fluid pressure to one of either the first or second concave surfaces, 20 or 22, the slit 14 will open and allow fluid to pass. However, at  
5 pressures below the predetermined value, the slit valve insures that there is no fluid flow. The relative geometries of the concave surfaces 20, 22, the length of the slit 24, and the valve body 14 determine the opening pressure of the valve 11 and whether a greater pressure is required for flow in one direction compared to flow in the other direction. Such a valve would be useful in applications where the use of a  
10 flange 12, as shown in Fig. 3, is undesirable or unfeasible, for example in a feeding tube or a drug delivery shunt.

Although the invention has been particularly shown and described with reference to certain preferred embodiments, it will be readily appreciated by those of ordinary skill in the art that various changes and modifications may be made therein  
15 without departing from the spirit and scope of the invention.